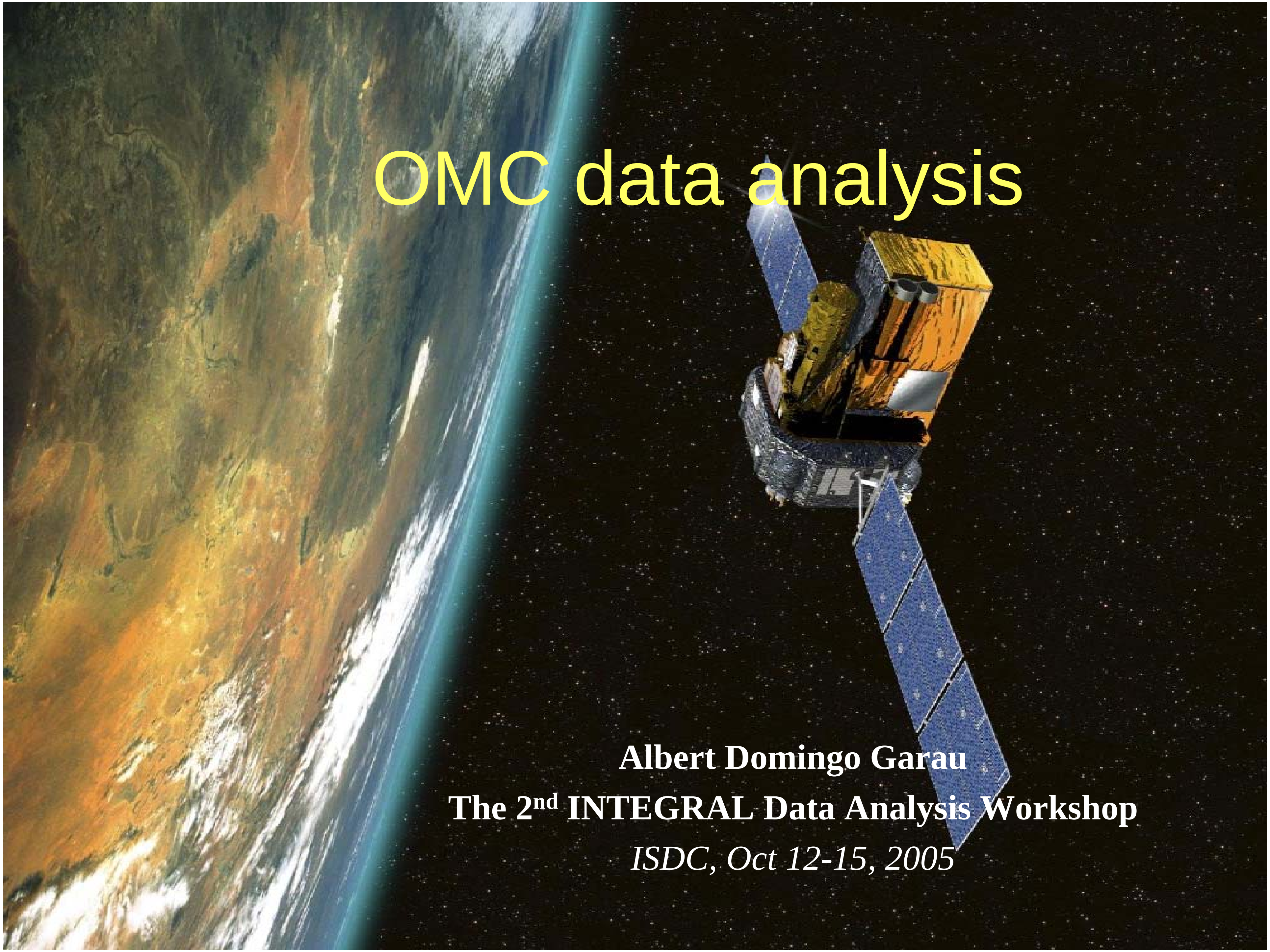


OMC data analysis

Albert Domingo Garau

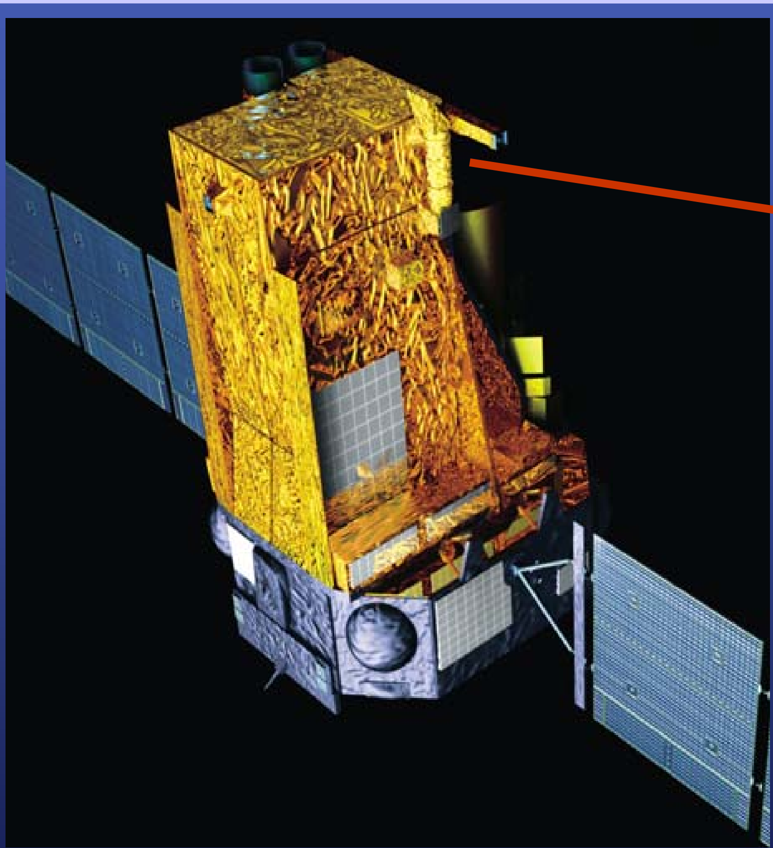
The 2nd INTEGRAL Data Analysis Workshop

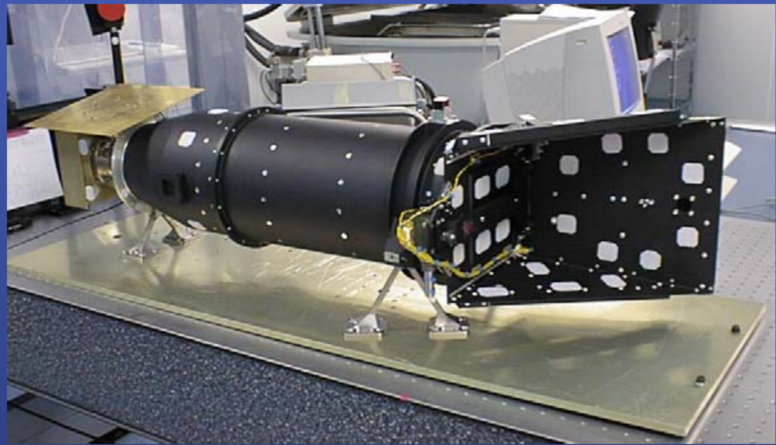
ISDC, Oct 12-15, 2005

Talk outline

- OMC main characteristics
- Some hints on operations
- OSA overview
- Algorithms description

The Optical Monitoring Camera: OMC



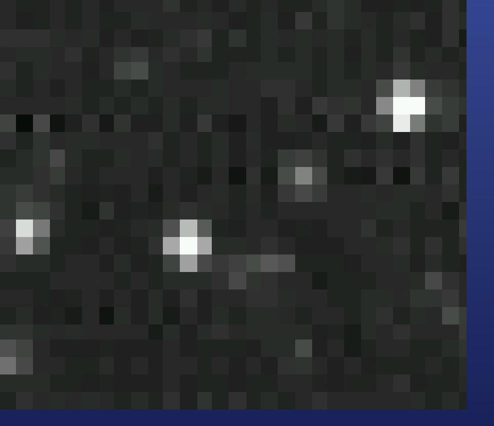


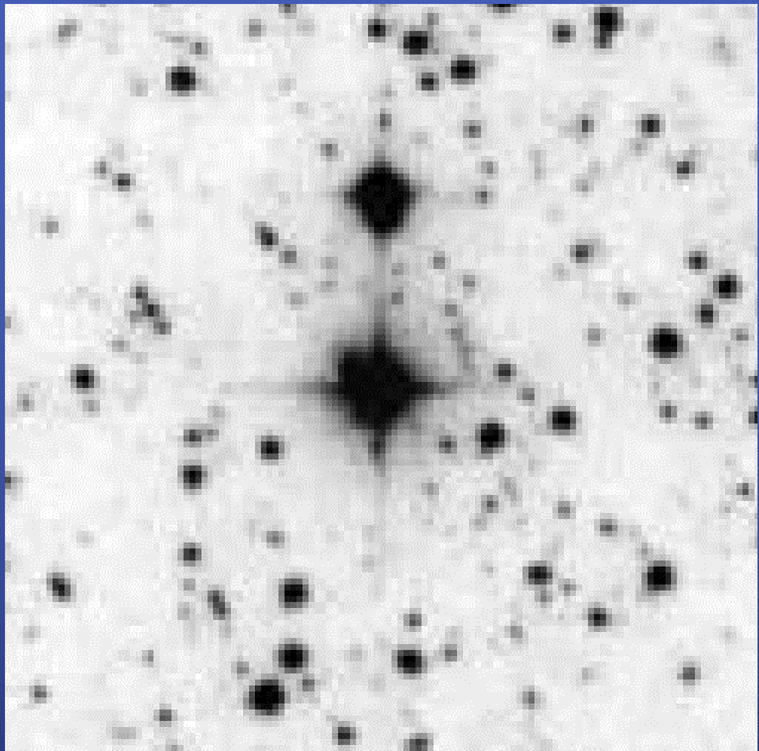
- OMC provides simultaneous optical photometry of the high energy sources being observed by IBIS, SPI and JEM-X
- It monitors also up to 100 potentially variable sources within its FoV in each pointing

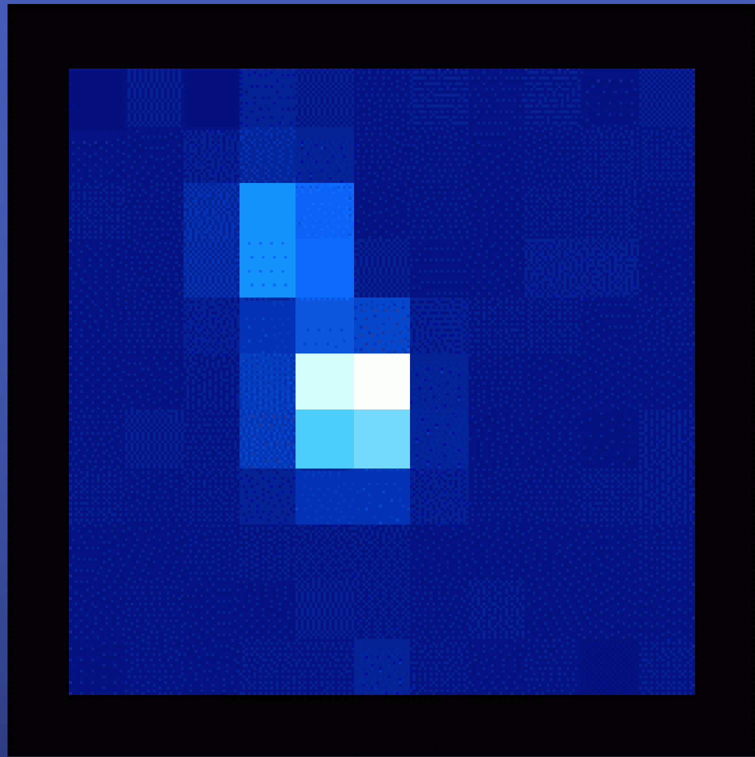
OMC main characteristics

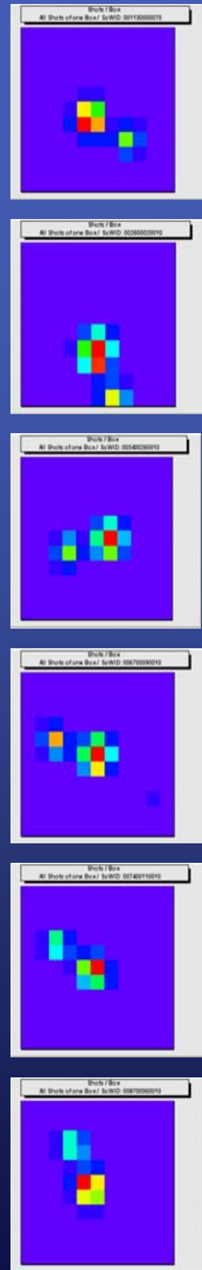
Field of view	5°×5°
Aperture	50 mm
Focal length	153.7 mm (f/3.1)
Optical throughput	> 70 % at 550 nm
System point spread function	Gaussian with FWHM ≈ 1.3 pix
CCD pixels	1056 x 2061 (1024 x 1024 image area)
Angular pixel size	17".5 x 17".5
CCD quantum efficiency	88 % at 550 nm
Time resolution	> 3s
Typical integration times	10 – 200 s
Wavelength range	V filter (centred at 550 nm)
Limiting magnitude	< 18 (V) (10×200 s, 3σ)
Sensitivity to variations	ΔV = 0.005 (V=9) to ΔV = 0.15 (V=16) *(depending on crowding)*

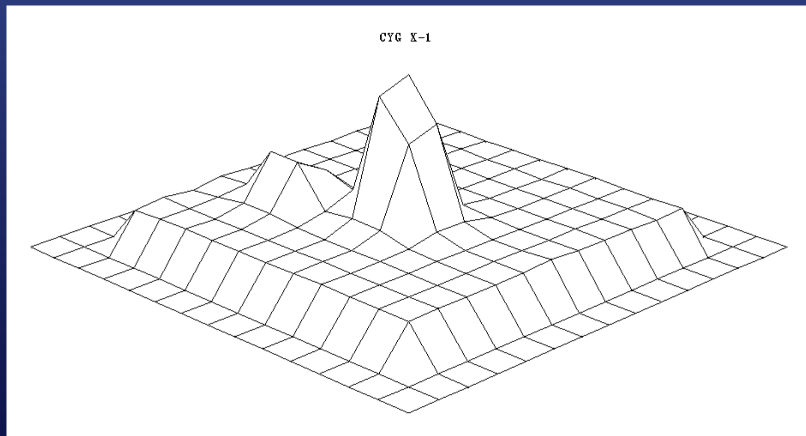
Large Magellanic Cloud region $5^o \times 5^o$





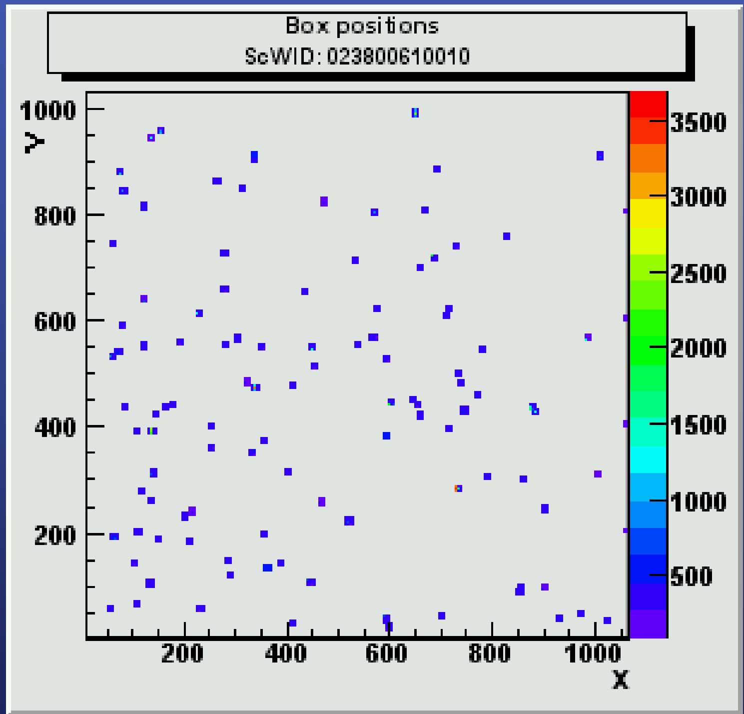





CYG X-1

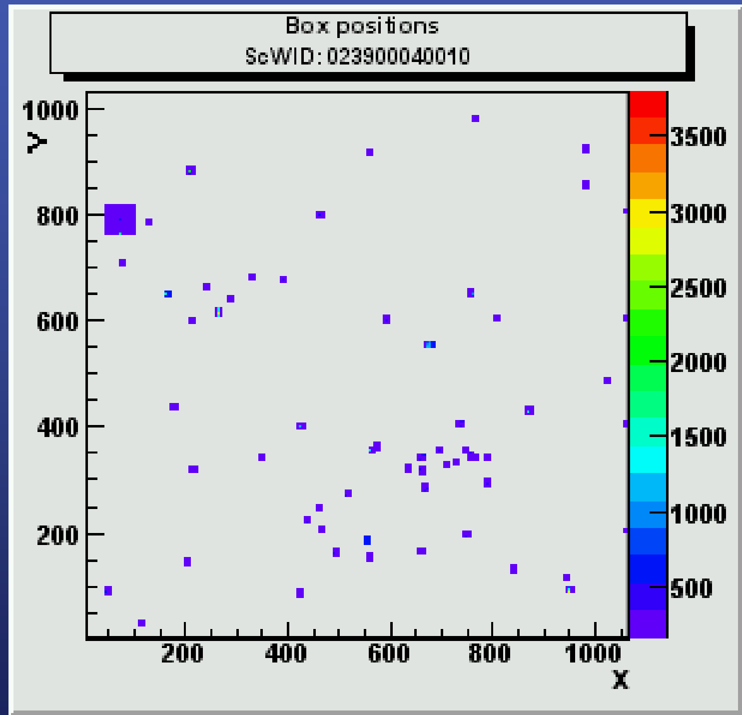
OMC sub-windows I

5°



5°

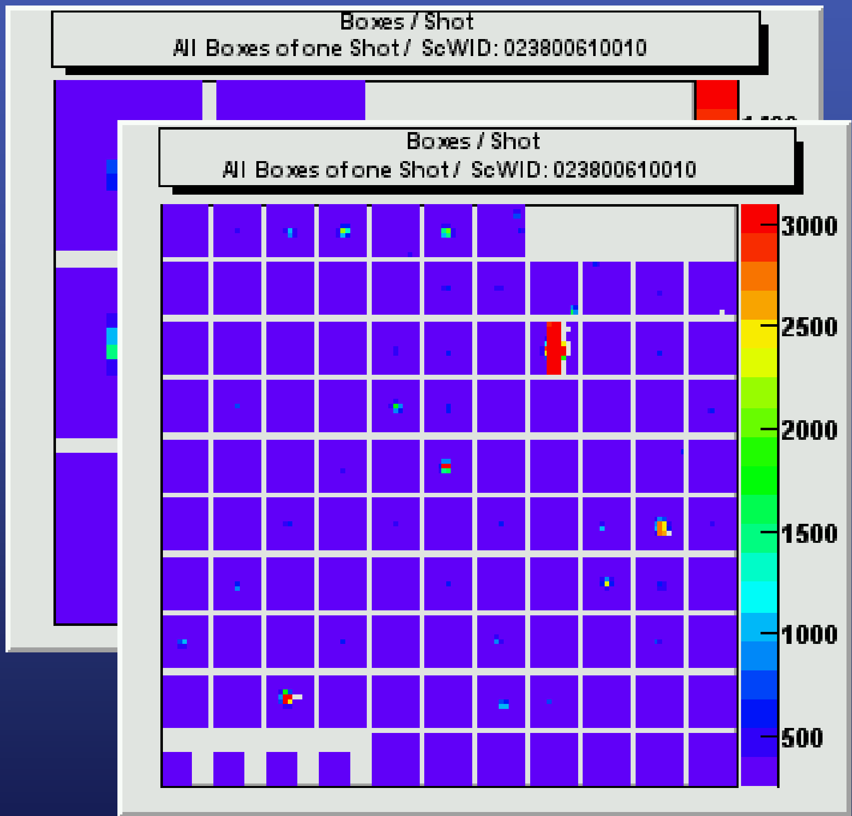
Point sources

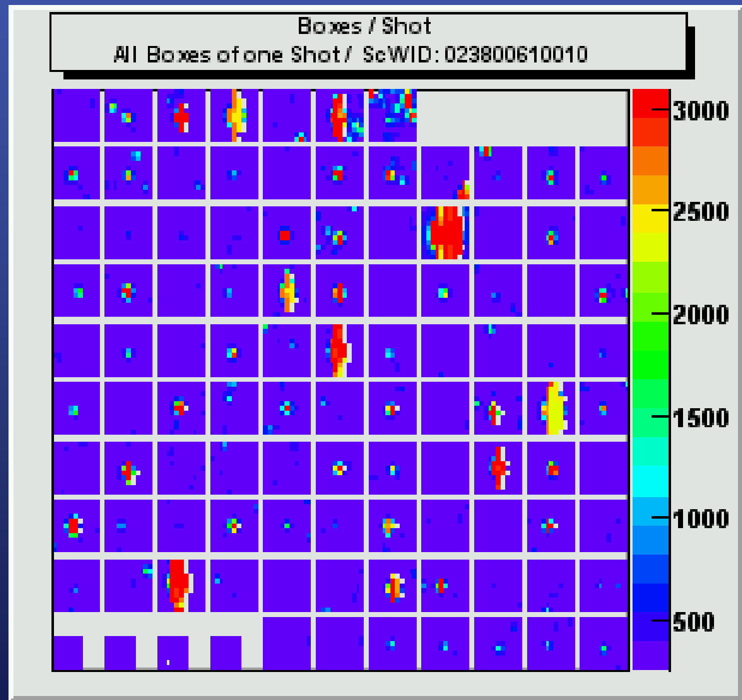


Extended source
(mosaic of sub-windows)

OMC sub-windows II

Photometric shot

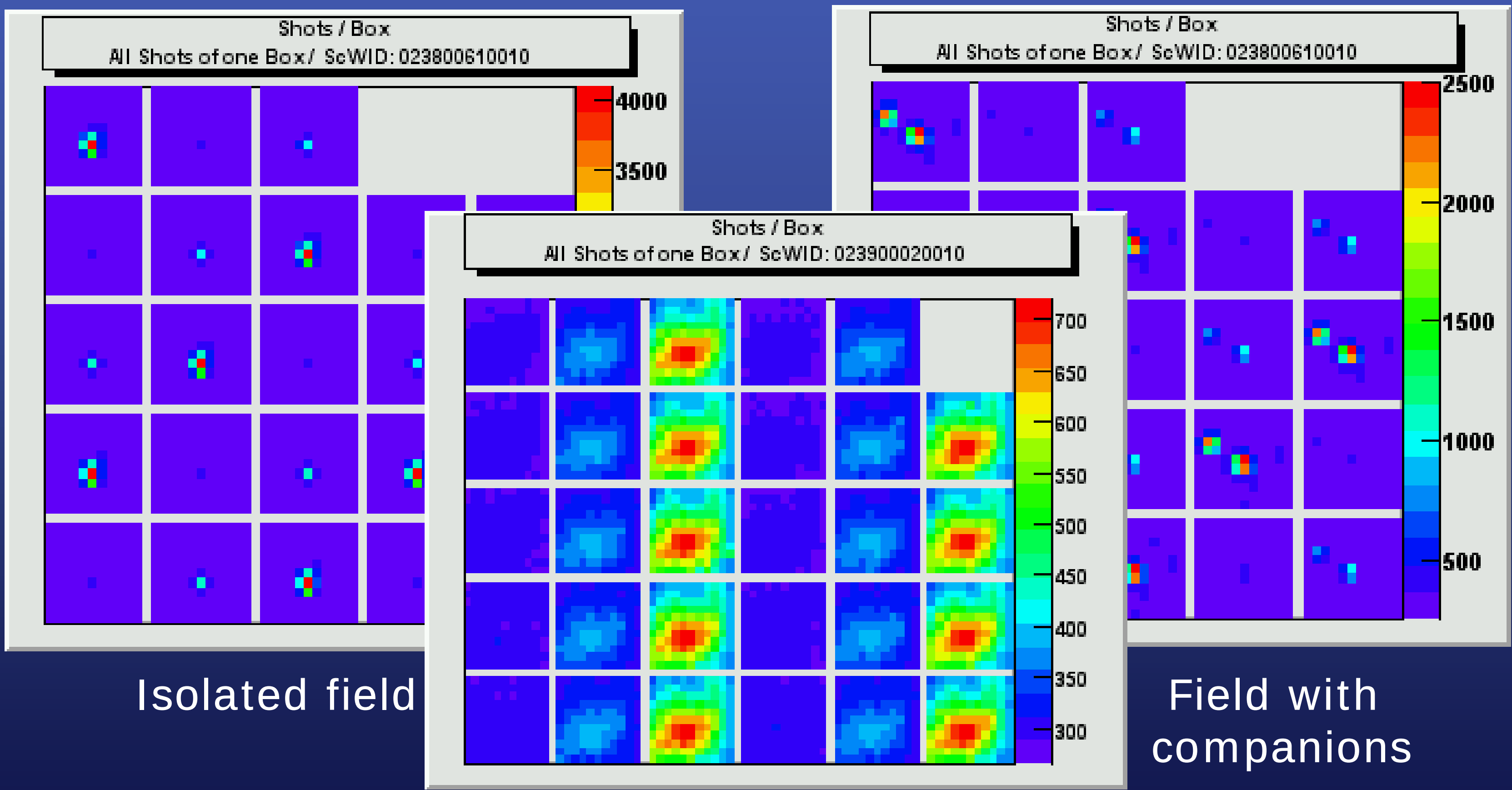




Science shot
10 seconds

Science shot
200 seconds

OMC sub-windows III

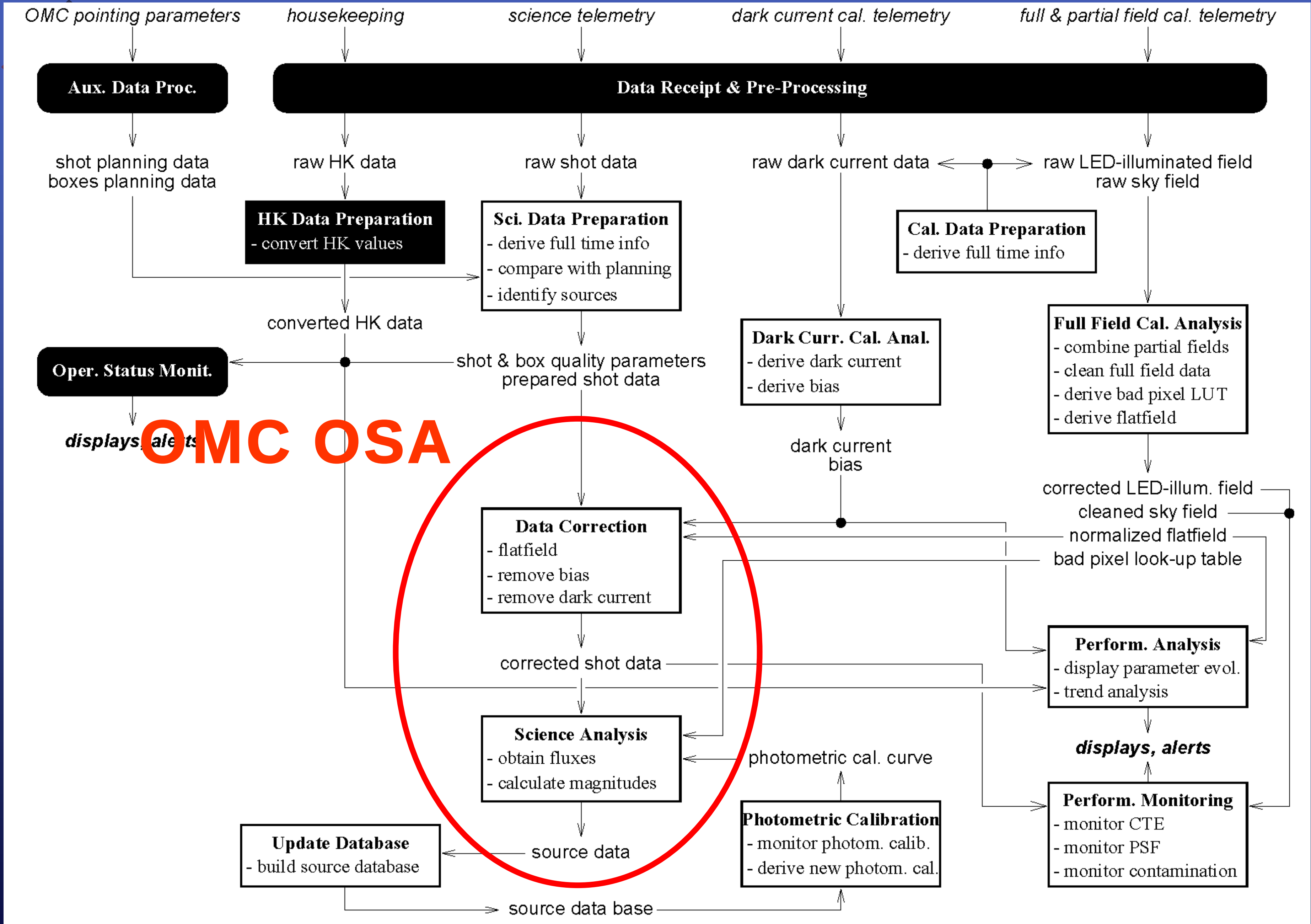


Isolated field

Field with companions

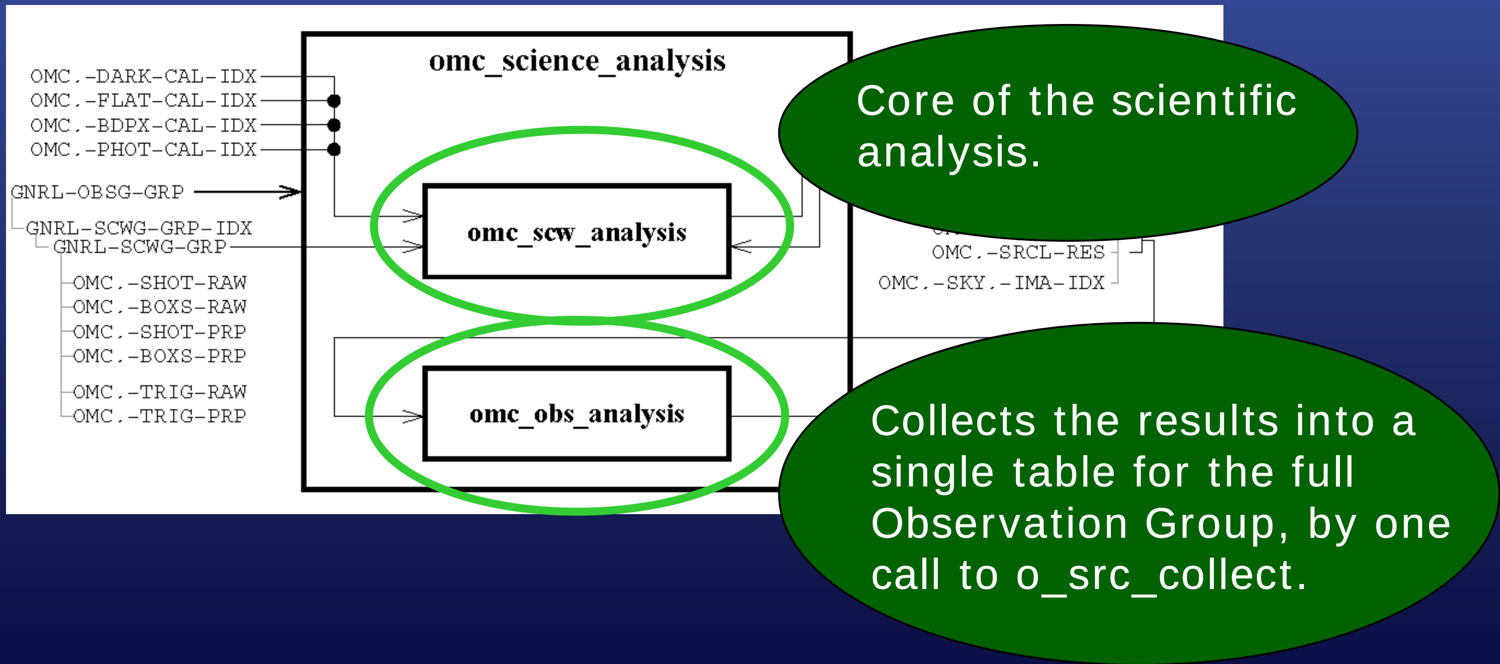
Crab Nebula

Overview of OMC data processing at ISDC


OMC pointing parameters
housekeeping
science telemetry
dark current cal. telemetry
full & partial field cal. telemetry
Aux. Data Proc.
Data Receipt & Pre-Processing
shot planning data
boxes planning data
raw HK data
raw shot data
raw dark current data
raw LED-illuminated field
raw sky field
HK Data Preparation
- convert HK values
Sci. Data Preparation
- derive full time info
- compare with planning
- identify sources
Cal. Data Preparation
- derive full time info
converted HK data
Dark Curr. Cal. Anal.
- derive dark current
- derive bias
Full Field Cal. Analysis
- combine partial fields
- clean full field data
- derive bad pixel LUT
- derive flatfield
Oper. Status Monit.
shot & box quality parameters
prepared shot data
displays, alerts
OMC OSA
dark current
bias
corrected LED-illum. field
cleaned sky field
normalized flatfield
bad pixel look-up table
Data Correction
- flatfield
- remove bias
- remove dark current
corrected shot data
Perform. Analysis
- display parameter evol.
- trend analysis
displays, alerts
Science Analysis
- obtain fluxes
- calculate magnitudes
photometric cal. curve
Update Database
- build source database
source data
Photometric Calibration
- monitor photom. calib.
- derive new photom. cal.
Perform. Monitoring
- monitor CTE
- monitor PSF
- monitor contamination
source data base

Off-line Scientific Analysis (OSA)

- A single script, omc_science_analysis runs the scientific analysis for an Observation Group of OMC data.
- For each Science Window Group it calls omc_scw_analysis and omc_obs_analysis.



Off-line Scientific Analysis (OSA)

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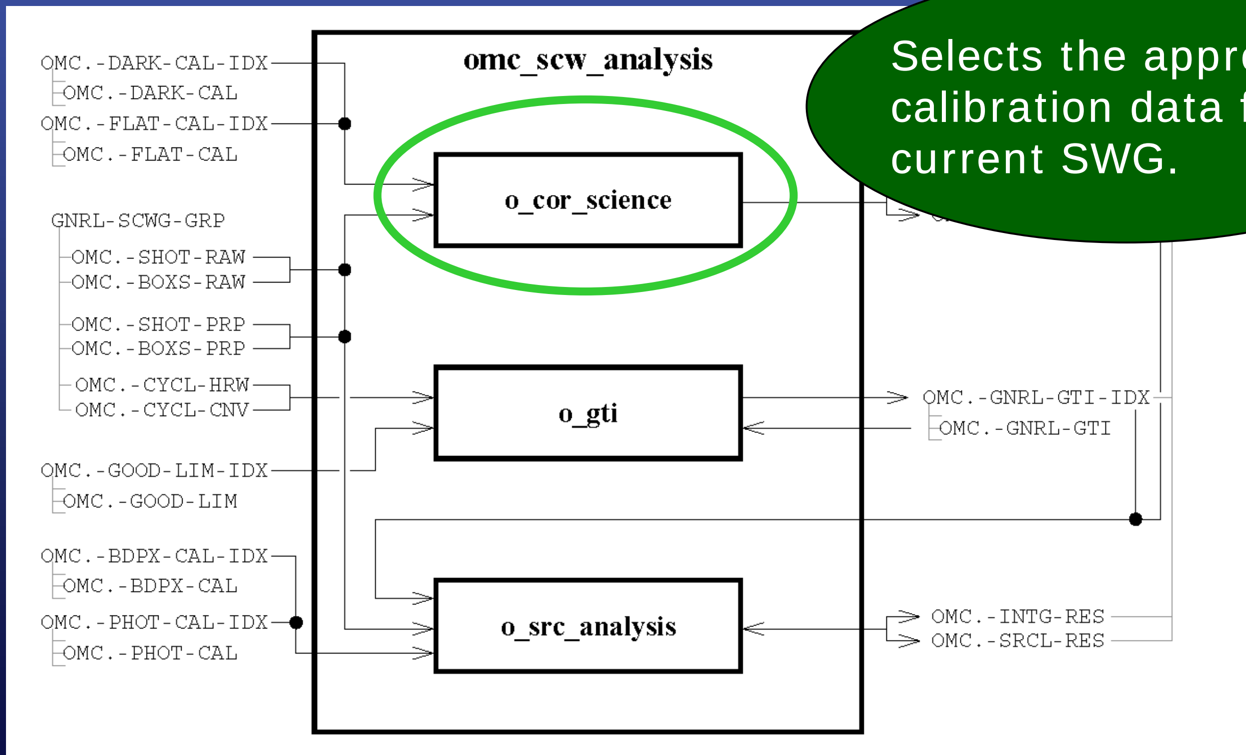
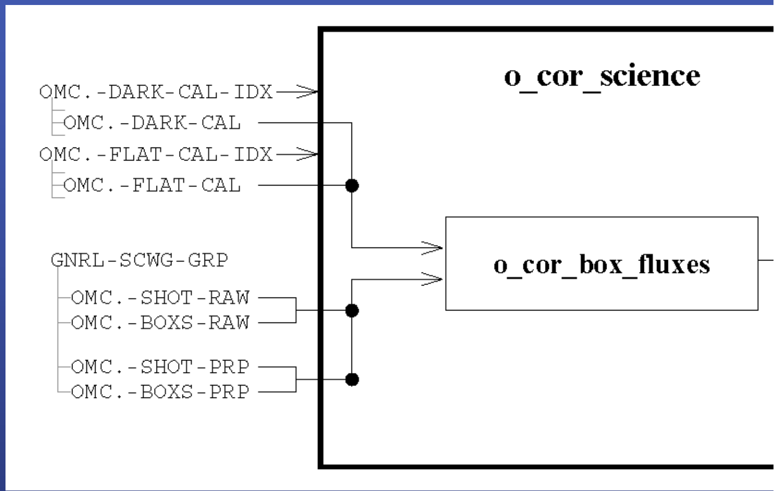
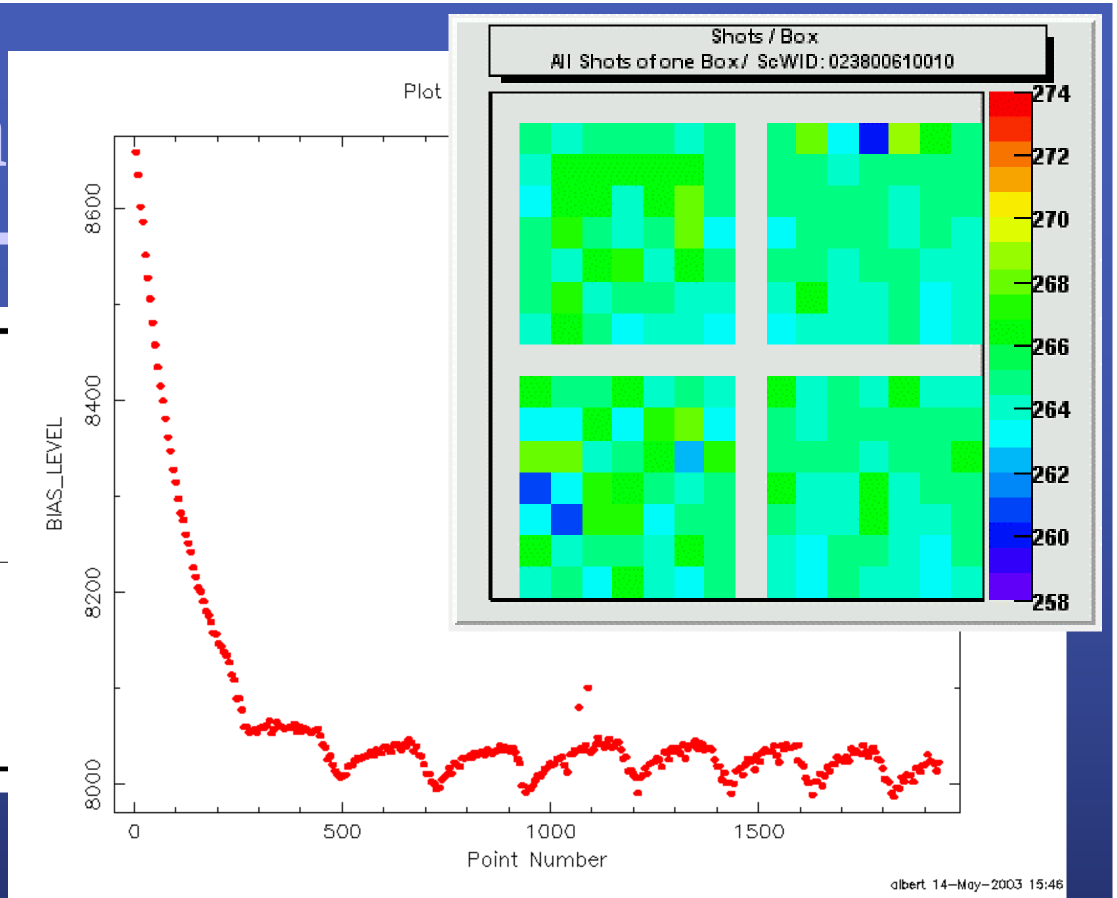


Selects the appropriate calibration data for the current SWG.

Data

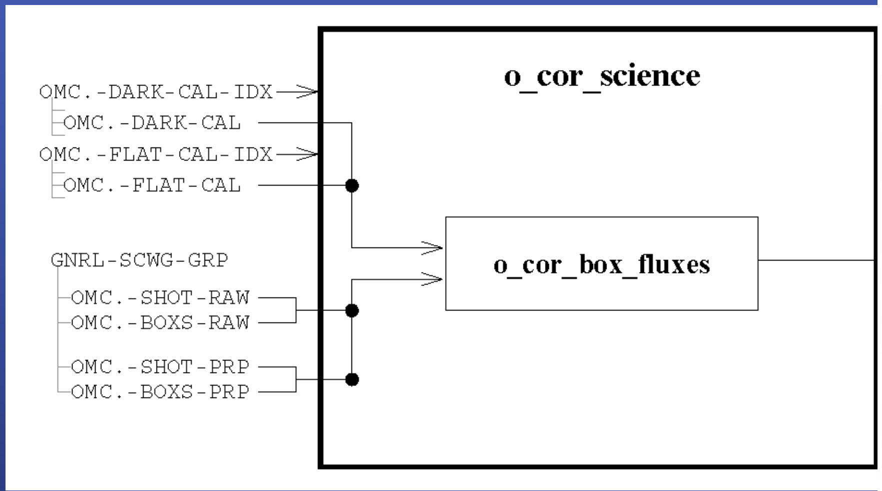


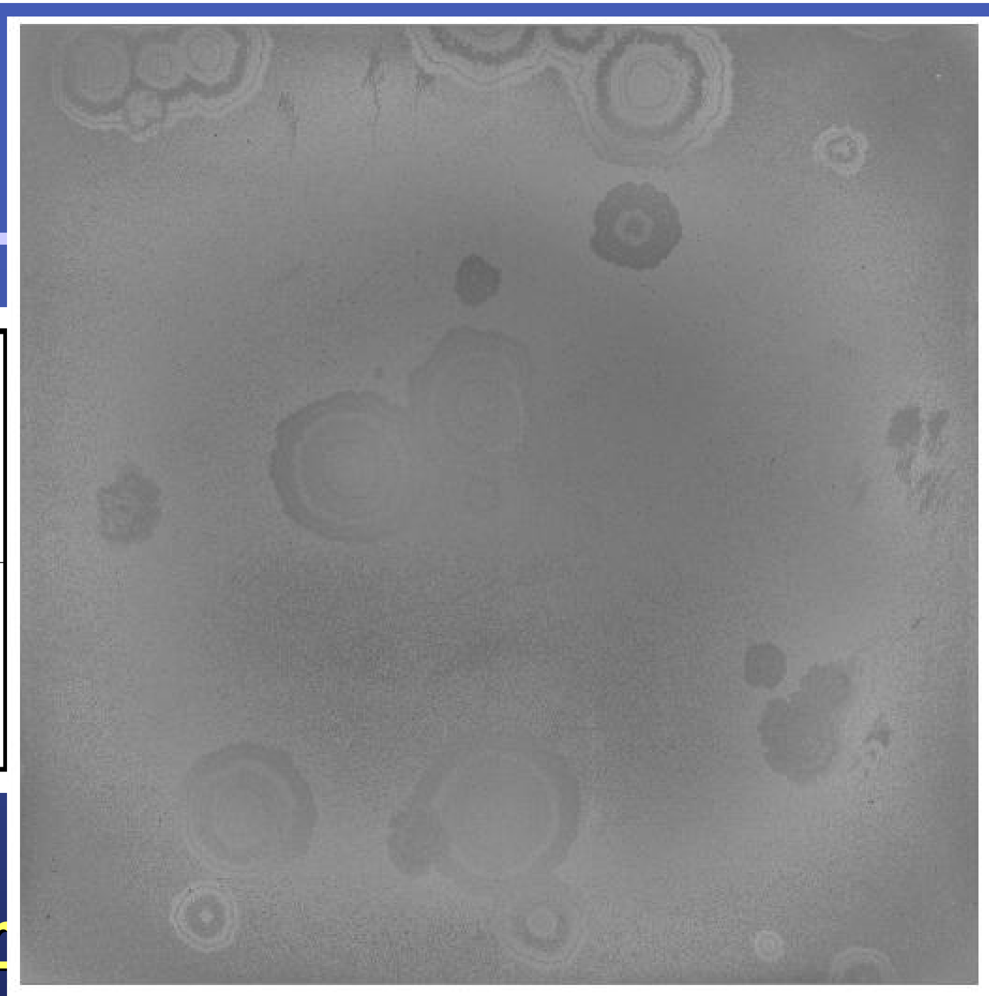


For each box in each shot:

- Bias determination (time dependent)
- Bias and dark current removal

Data C

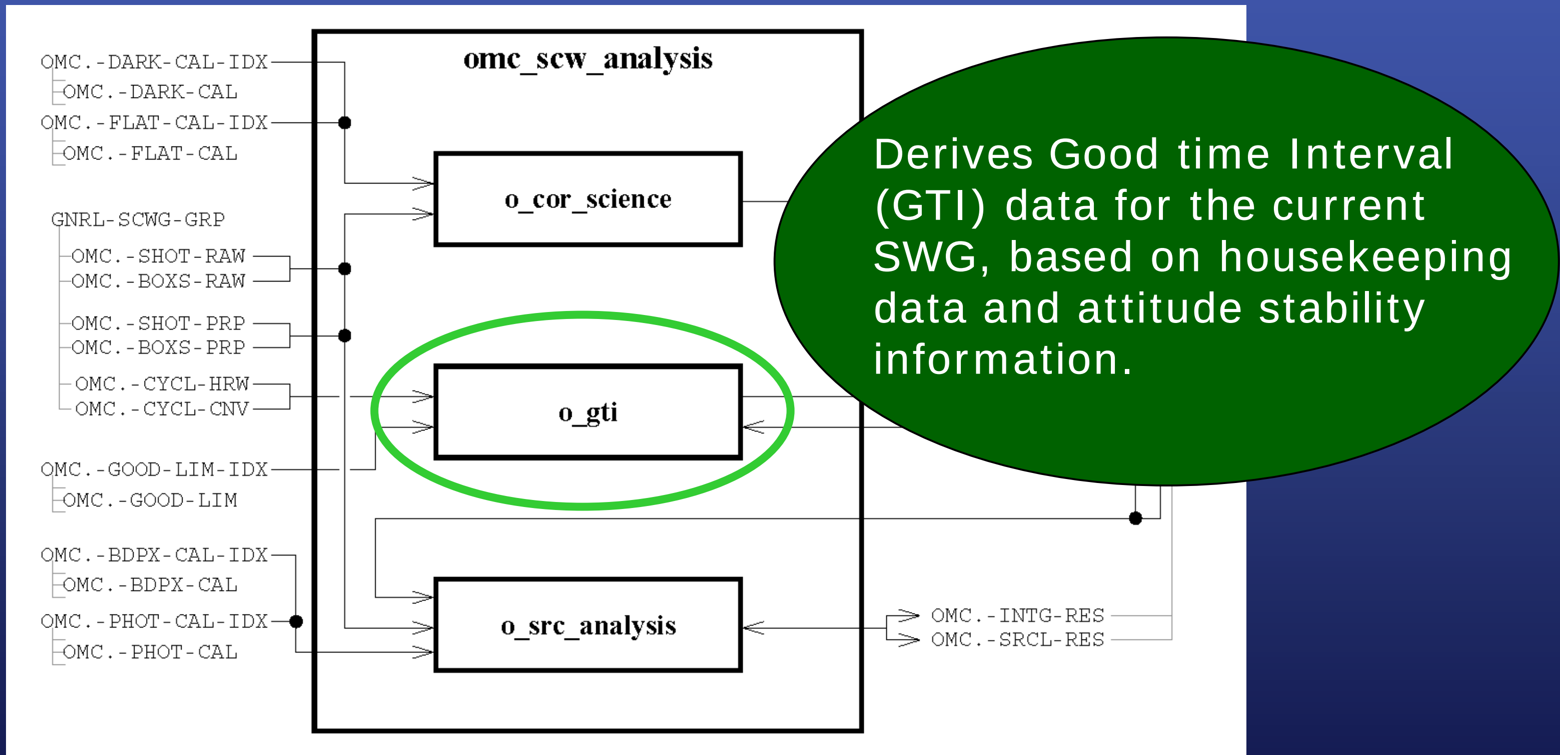




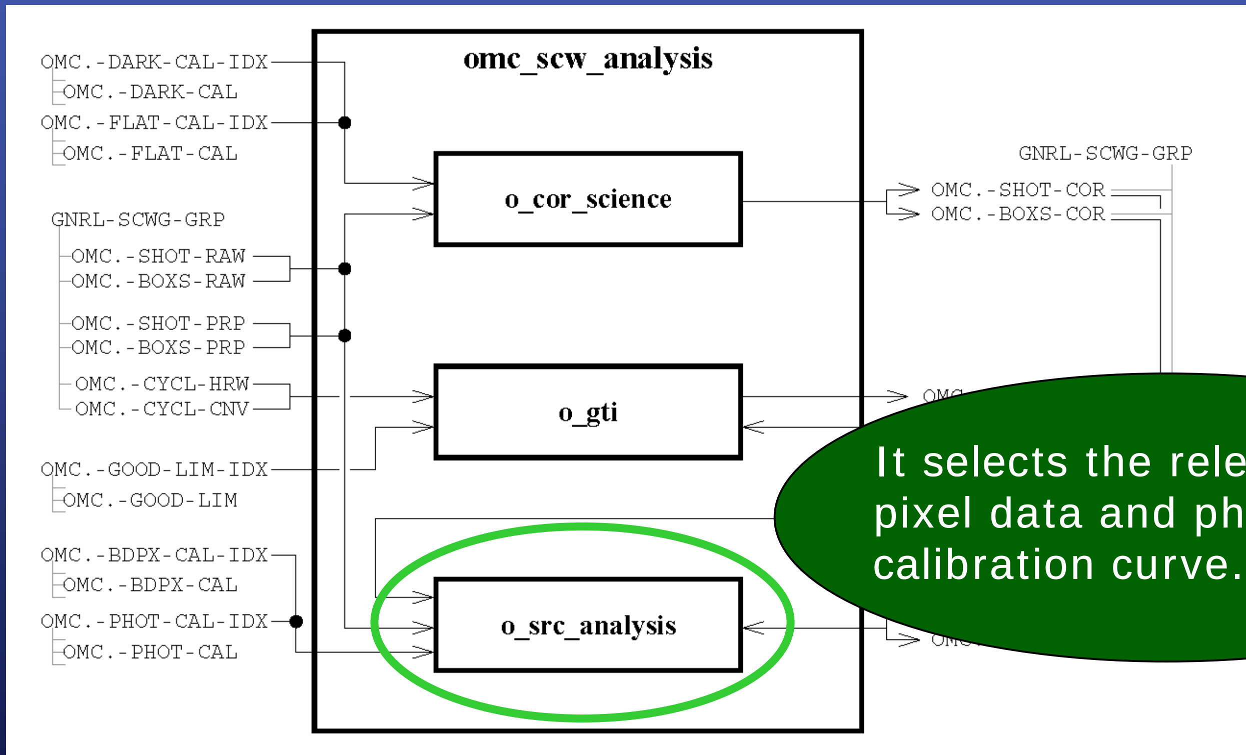
For each box in each

- Bias determination (time dependent)
- Bias and dark current removal
- Flatfield correction (pixel sensitivity)

Off-line Scientific Analysis (OSA)



Off-line Scientific Analysis (OSA)

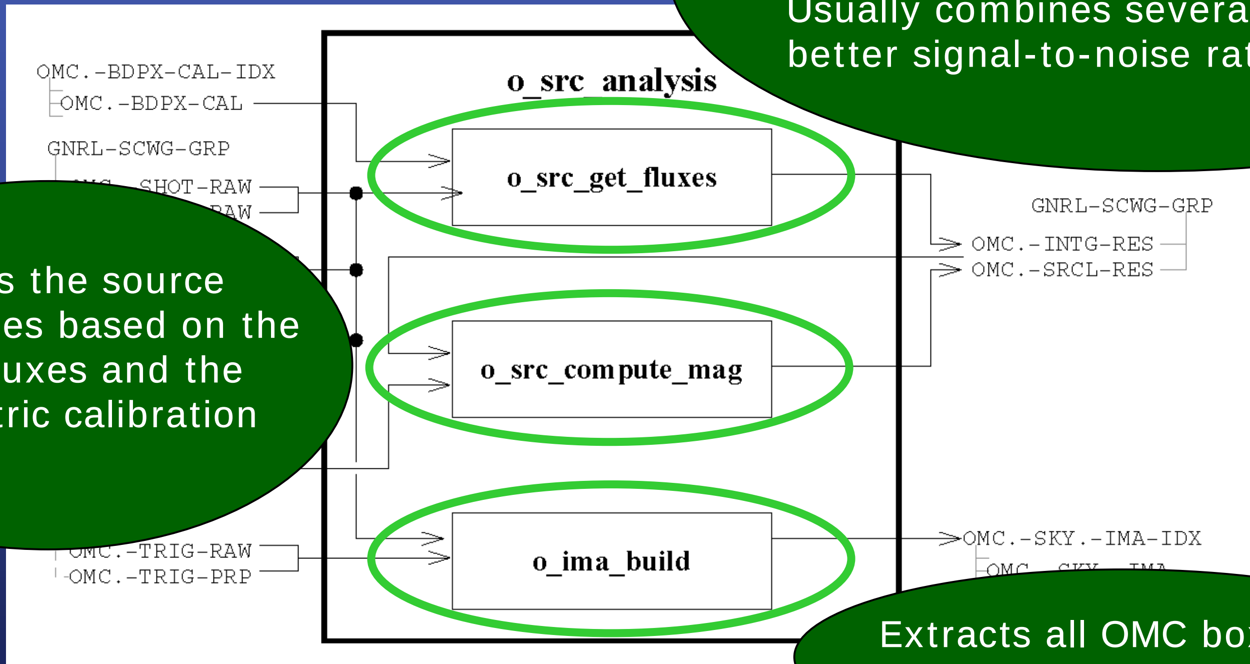


It selects the relevant bad pixel data and photometric calibration curve.

Science Analysis

Performs aperture photometry to obtain the fluxes of the individual sources.

Usually combines several shots to obtain a better signal-to-noise ratio.

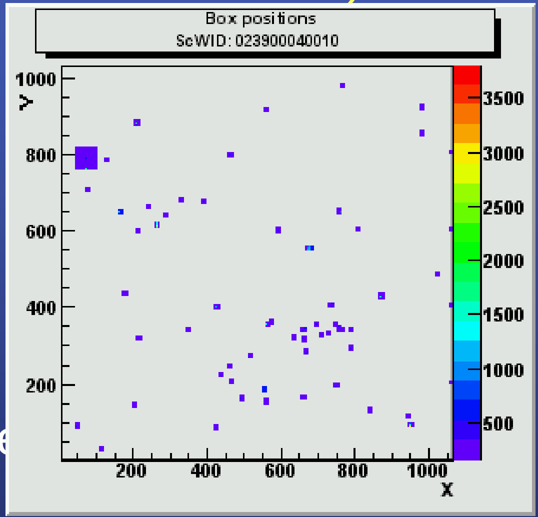


Calculates the source magnitudes based on the derived fluxes and the photometric calibration curve.

Extracts all OMC boxes in a SWG. It builds sky images.

Flux derivation (o_src_get_fluxes) I

Process photometric and science targets (corrected sub-windows)



Perform some checks on:

- GTI
- prp data to select good shots
- prp data to select good boxes
- Bad pixels
- Saturated pixels
- User parameters (e.g. shot integration time

- Detect mosaics of sub-windows (extended sources)

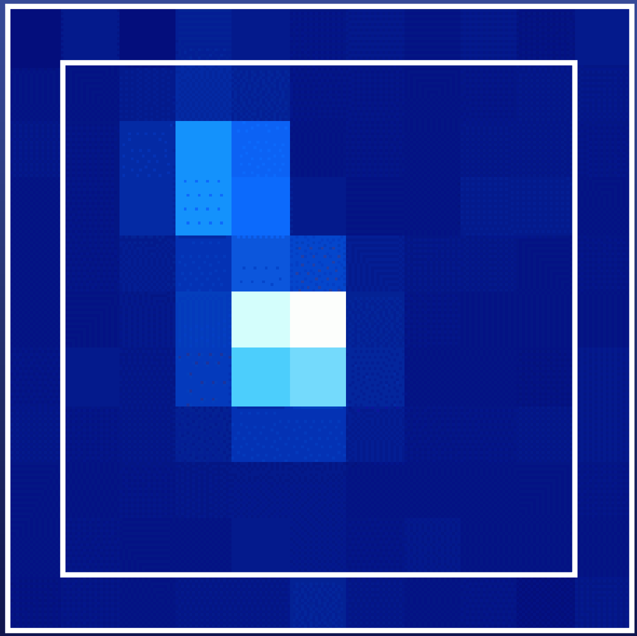
Combine several shots to get a better signal-to-noise ratio

(the number of shots combined depends on elapsed time given by the user as a parameter)

Flux derivation (o_src_get_fluxes) II

Compute and subtract the sky background from each sub-window

- Uses the 11×11 exterior rim
- Rejection of high and low pixels to avoid cosmic rays and noisy pixels

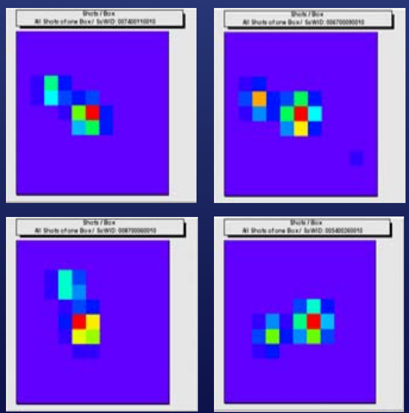


Flux derivation (o_src_get_fluxes) III

Perform aperture photometry in combined boxes

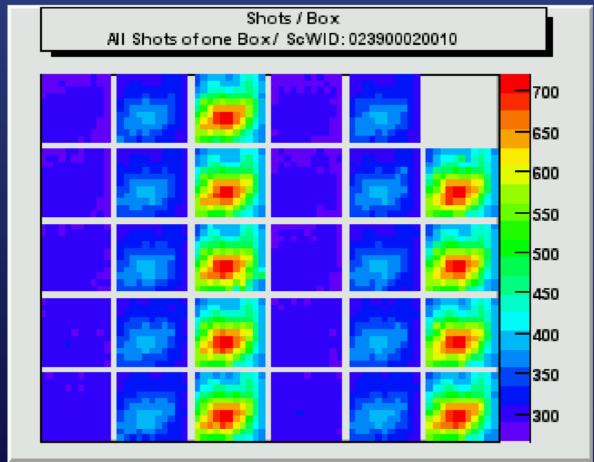
- Compute the source centroid (iterative process)
- Integrate the flux in 1×1, 3×3 and 5×5 apertures using a pixel sub-sampling method
- Correct for different apertures integrating the PSF

Detect source contamination, non point sources, saturated sources or wrong sources by analysing the shape of the PSF



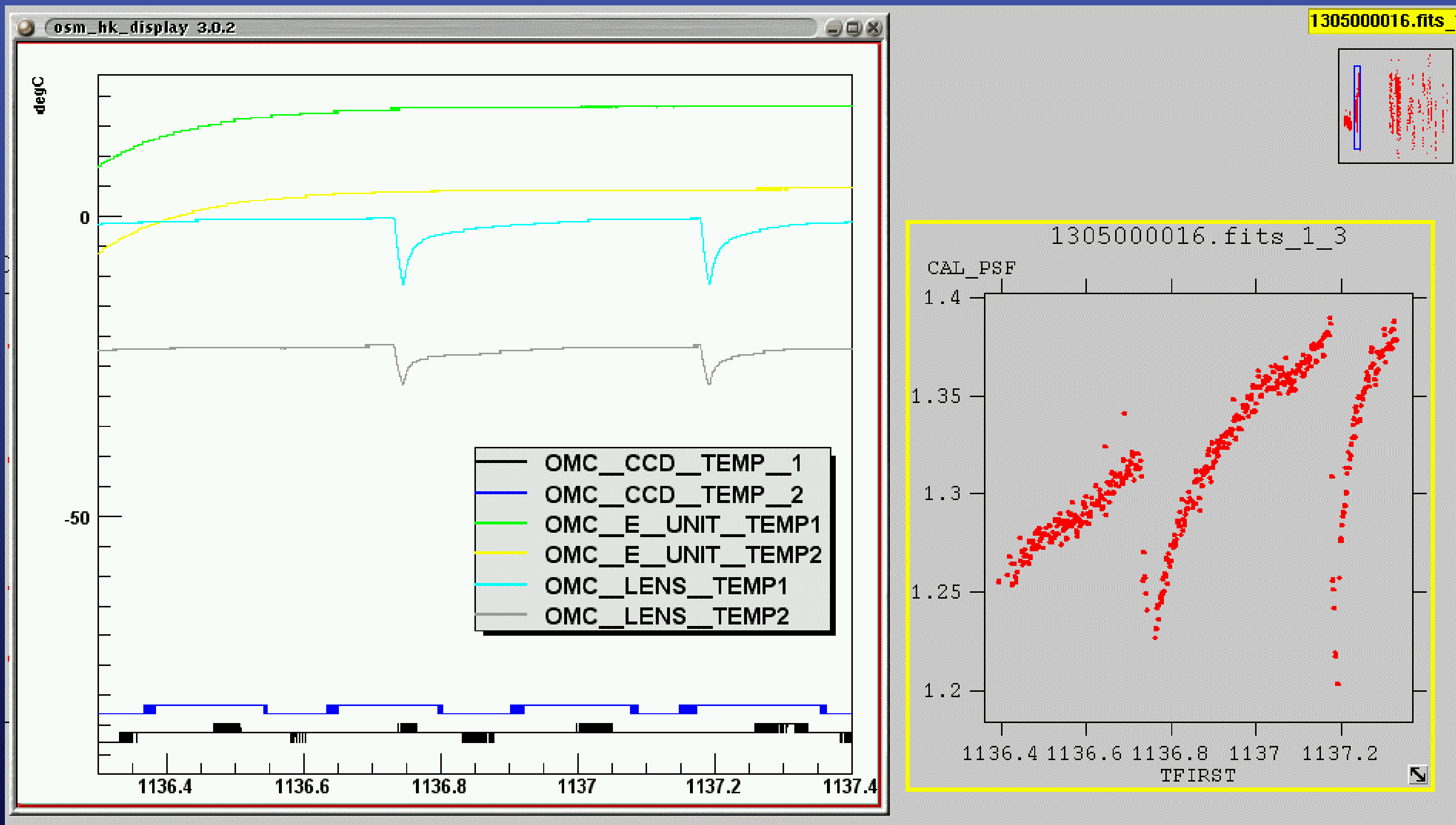
Cyg X-1

Crab Nebula

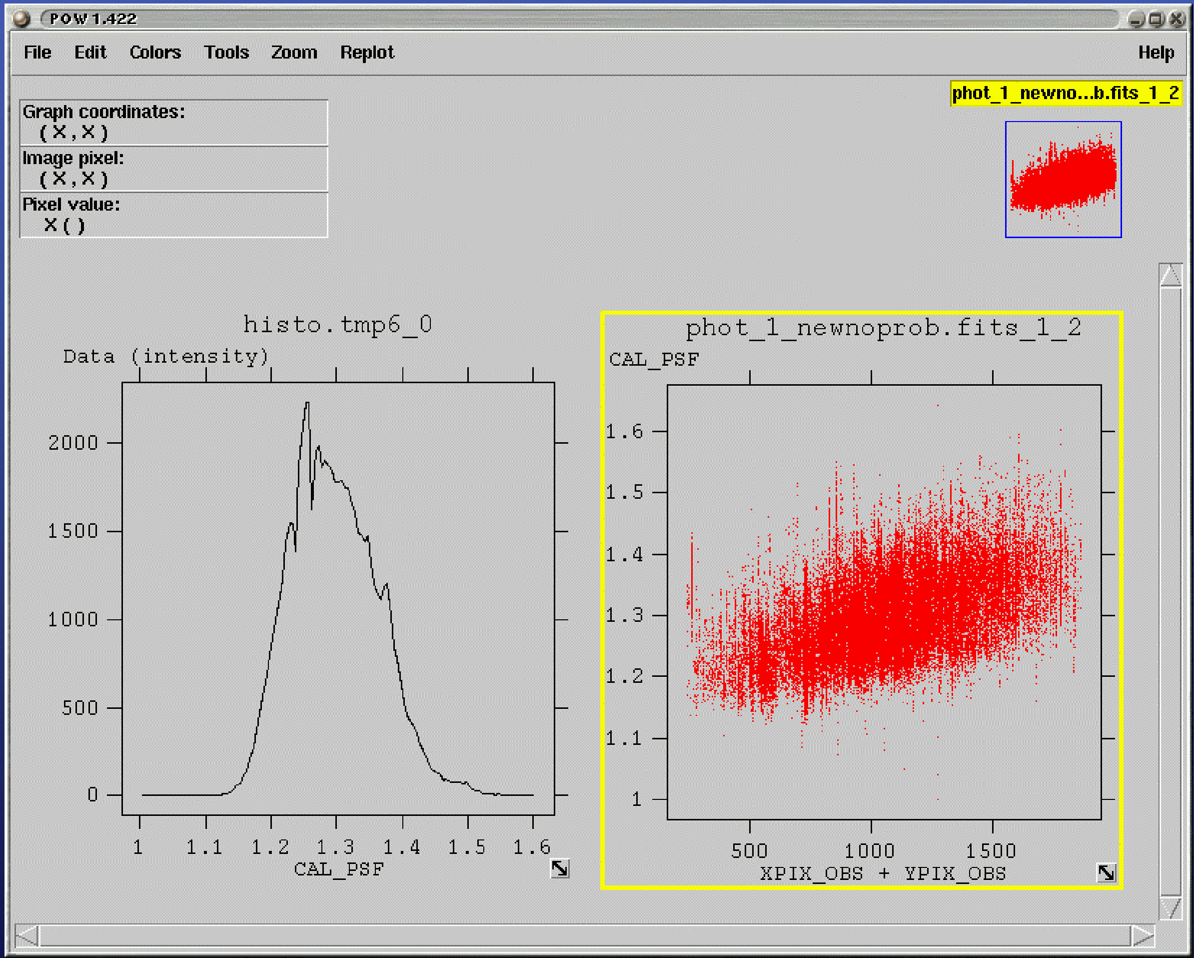


PSF width determination I

- PSF depends on lens temperature, but…
  - Modelling is difficult



PSF width determination II



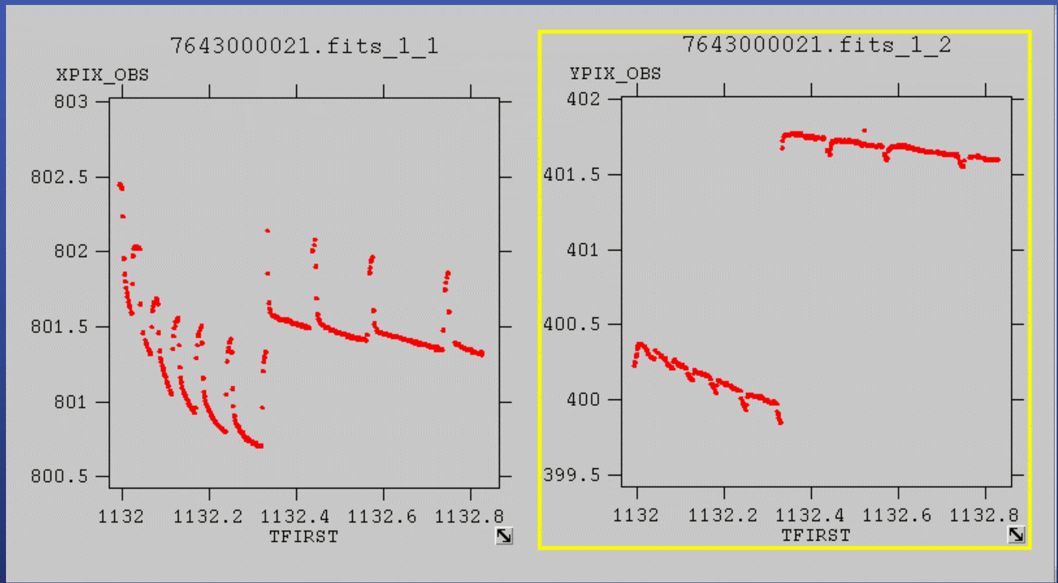
- PSF width depends on pixel location over the CCD.
- Relation is linear
- Probably the detector is slightly tilted.

PSF width determination III

Implemented solution:

- Use faint photometric stars to compute the PSF width
- Iterative method to minimize the residuals in each pixel according to a Gaussian PSF profile:
  - ✓ Fitted values:
    - ➢ X and Y centroid
    - ➢ PSF width
- Combine the same number of shots as in science integrations
  - ✓ Advantage: it is an effective PSF

Source centroid I



Source centroid changes with time

Why?

1. OMC thermoelastic deformations
2. Variation of lens temperature

Source centroid II

Implemented solution:

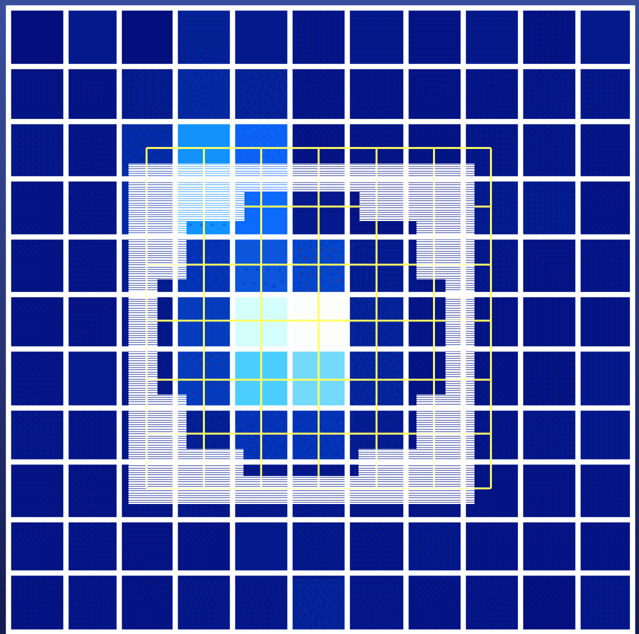
- Similar to the PSF width calculation
- Iterative method to minimize the residuals in each pixel according to a Gaussian PSF profile and the previously computed width:
  - ✓ Fitted values:
    - ➢ X and Y centroid

- Faint photometric stars are used to derive a WCS solution for each effective integration, giving an accuracy better than 2” in most cases. Implemented also in o_ima_build.

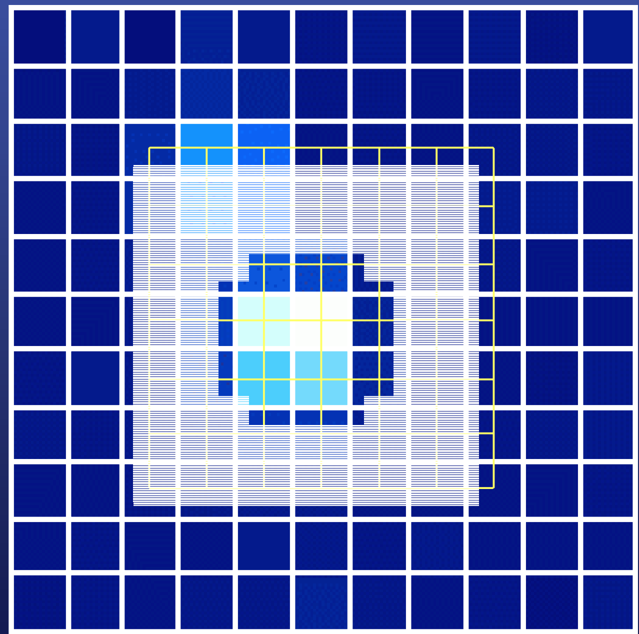
Photometric apertures

Main goals

- Minimize the effect of source companions
- Correct the displacements of the source centroids



Effective area = (25-6) pixel^2



Effective area = (9-1) pixel^2

And now…

Please,
try OMC OSA.

We will be delighted to answer
any question at any time.